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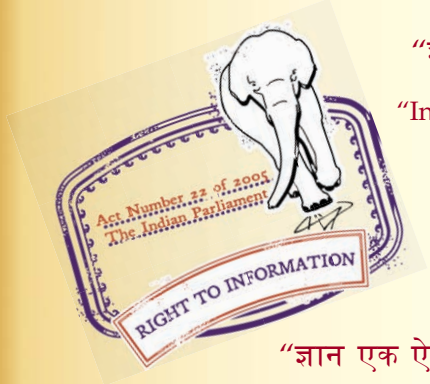

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IS : 4943 - 1968
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Indian Standard

ASSESSMENT OF BUTT AND FILLET FUSION WELDS IN STEEL SHEET, PLATE AND PIPE

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 4 *March* 1969

Indian Standard

ASSESSMENT OF BUTT AND FILLET FUSION WELDS IN STEEL SHEET, PLATE AND PIPE

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ASSESSMENT OF BUTT AND FILLET FUSION WELDS IN STEEL SHEET, PLATE AND PIPE

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 31 December 1968, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 Assessment of the quality of fusion welds whether for approval of welding procedure or for testing of welders, is a necessary requirement prior to undertaking any important welded construction.

0.3 Tests for such assessment are included in most of the welding codes. These tests generally involve considerable machining work for preparation of the test specimens, which is a disadvantage when a large number of test pieces are required to be tested. This standard for assessment of butt and fillet fusion welds in steel has been prepared with a view to providing simple tests involving less machining work in preparation of the test specimen.

0.4 In preparing this standard considerable assistance has been derived from DIN 50127 'Testing of steel — notched tensile test specimens, notched pipe tensile test specimens and notched bend test specimens, bend over test specimens and wedge test specimens for the assessment of butt and fillet fusion welds' issued by Deutscher Normenausschuss, Berlin.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard prescribes notched tensile and notched bend tests for assessing the quality of butt welds in steel sheet, plate and pipe and bend over test and wedge test for assessing the quality of fillet welds in steel plate.

*Rules for rounding off numerical values (*revised*).

1.2 Notched tensile test included in this standard is applicable to steel sheet, plate and pipe of thickness up to and including 20 mm. The bend over and wedge tests are applicable to steel plates of thickness between 5 to 12 mm.

1.3 These tests could be used in lieu of only those tests which are used for assessing similar qualities, and are not meant for replacing all the tests specified in the various codes. For example, where radiographic tests, or fillet weld shearing tests to ascertain the strength of the joint are specified, these will have to be done in addition to the tests specified in this standard.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions laid down in IS : 812-1957* shall apply.

3. TYPES OF TESTS USED AND THEIR PURPOSE

3.1 The tests included in this standard for assessing the quality of butt welds are:

a) Notched tensile test,

b) Notched root and face bend tests, and

c) Notched free bend test.

For assessing the quality of fillet welds, the tests included are:

a) Bend over test, and

b) Wedge test.

The purpose served by each of these tests is described in **3.1.1** to **3.1.5.**

3.1.1 *Notched Tensile Test* — In this test, the test specimen is so designed that the fracture is induced in the weld joint. This enables not only the tensile strength of the actual weld being ascertained, but also the quality of the weld judged from the appearance of the fracture.

3.1.2 *Notched Root and Face Bend Test* — In this test, due to the form of the test specimen, it is primarily the weld which deforms under bending so that fracture generally occurs in the weld itself. This enables quality of the weld being judged from the appearance of the fracture and the angle of bending before the appearance of cracks provides a measure of deformability of the weld metal.

*Glossary of terms relating to welding and cutting of metals.

3.1.3 *Notched Free Bend Test* — In this test, since the elongation of the weld metal in tension is ascertained, it provides a measure of ductility of the weld metal.

3.1.4 *Bend over Test* — The object of this test is to assess the quality of fillet welds from the appearance of weld face and the fractured surfaces of the weld.

3.1.5 *Wedge Test* — The object of this test is to assess the quality of fillet welds from the appearance of weld face and the fractured surfaces of the weld.

4. TESTING OF BUTT WELDS IN SHEET, PLATE AND PIPE

4.1 Butt Welds in Sheet, Plate and Pipe (Outside Diameter More than 89 mm)

4.1.1 *Welding and Preparation of Test Pieces* — Two pieces of sheets or plates of the same material and thickness, having a minimum width of 110 mm and minimum length depending on the number of test specimens (minimum one tensile and two bend test specimens, one each for root bend and face bend respectively) required, shall be cut, prepared and welded together as shown in Fig. 1 and 2. The straight specimen (Fig. 1) should be used when it is intended to assess the physical properties of the entire joint while the notched specimen (Fig. 2) should be used when it is intended to assess the physical properties of the weld seam. The edge preparation shall be in accordance with the appropriate codes and specifications. Holes shall be drilled, preferably by jig drilling, in the centre of the weld face and test pieces shall be cut either by sawing or by flame cutting as shown in Fig. 1 and 2. Flame cutting is, however, not permissible in the case of hardenable steels which are likely to be affected by the heat of the flame. The diameter of the holes, the width of the specimens, the depth of notch, and the distance between the centres of two consecutive holes, for the different thicknesses of sheets and plates shall be as given in Tables 1 and 2. The centres of the holes shall not deviate from the centre line of the weld by more than 1 mm in the case of material below 5 mm thickness and by 2 mm in the case of material above 5 mm thickness. The holes shall preferably be drilled from the root side. When flame cutting is used the cutter shall be operated from the edge of the test piece towards the hole. Any burrs left by the drilling, sawing or flame cutting operations shall be removed by filling or other means. The weld bead shall be machined down flush with the surface of the plate on both sides of the specimens.

4.1.1.1 In the case of pipes with outside diameter more than 89 mm, two lengths of pipe of the same material and thickness and each at least 110 mm long shall be welded together to form a test piece which shall then be drilled and cut as described above so as to obtain a number of test specimens.

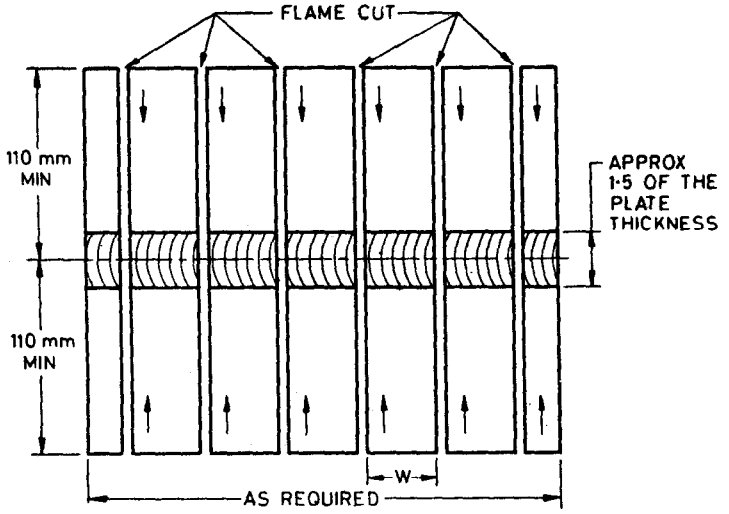


FIG. 1 TEST PIECE FOR THE PREPARATION OF STRAIGHT TENSILE AND BEND TEST SPECIMENS

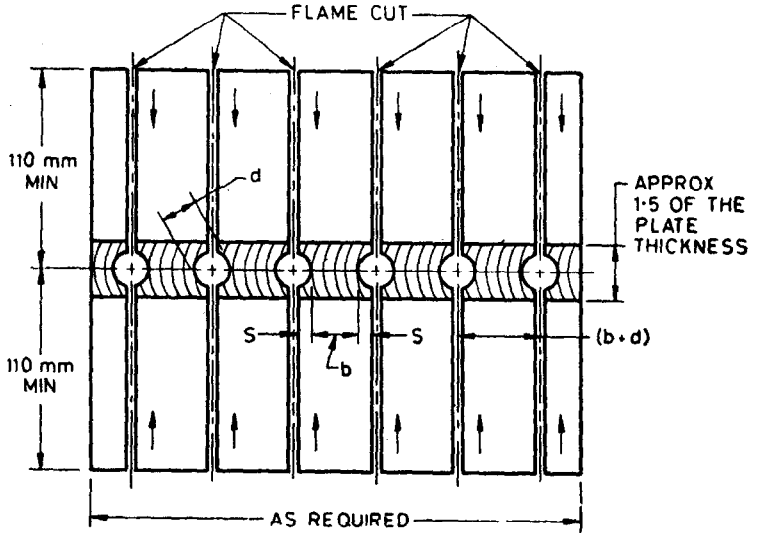


FIG. 2 TEST PIECE FOR THE PREPARATION OF NOTCHED TENSILE AND NOTCHED BEND TEST SPECIMENS

TABLE 1 DIMENSIONS OF STRAIGHT TENSILE AND STRAIGHT BEND TEST SPECIMENS

(*Clause* 4.1.1)

Thickness of Plate t mm	Width of Test Specimen w mm	Machining of Specimens	
		Bend Test	Tensile Test
Up to and including 10	25	Weld bead to be machined down flush with the plate surface on both sides. Edges of holes on side in tension to be radiused at $r = 0{\cdot}1\ t$	Weld bead to be down flush with the surface of the plate on both sides. Edges of holes to be deburred but not radiused
Over 10 up to and including 16	35	Weld bead to be machined down on root side. Edges of holes on side in tension to be radiused, at $r = 0{\cdot}1\ t$	
Over 16 up to and including 20	45		

TABLE 2 DIMENSIONS OF NOTCHED TENSILE AND NOTCHED BEND TEST SPECIMENS

(*Clause* 4.1.1)

Thickness of Plate t	Diameter of Hole d	Width of Test Specimen b	Depth of Notch s *Min*	Hole Pitch Centre to Centre $(b + d)$	Machining of Specimens	
					Bend Test	Tensile Test
mm	mm	mm	mm	mm		
Up to and including 10	10	15	3	25	Weld bead to be machined down flush with the plate surface on both sides. Edges of holes on side in tension to be radiused at $r = 0{\cdot}1\ t$	Weld bead to be down flush with the surface of the plate on both sides. Edges of holes to be deburred but not radiused
Over 10 up to and including 16	15	20	5	35	Weld bead to be machined down on root side. Edges of holes on side in tension to be radiused at $r = 0{\cdot}1\ t$	
Over 16 up to and including 20	20	25	7·5	45		

4.1.2 *Notched Tensile Test*

4.1.2.1 *Procedure* — The least width and the corresponding thickness of the specimen prepared as in **4.1.1**, at the notched portion, shall be measured in millimetres and the test specimen which is pressed flat at both ends over a length of approximately 60 mm shall be pulled apart in a conventional tensile testing machine equipped with flat wedge grips and the maximum load at rupture shall be determined. The tensile stress in kgf/mm^2 shall be obtained by dividing the maximum load by the cross-sectional area (width × thickness).

4.1.2.2 *Assessment of notched tensile test* — Fractured ends of the broken test piece shall be visually examined and the nature of fracture, that is, whether ductile (silky) or brittle (crystalline) shall be recorded. The fracture shall be free from defects, such as slag inclusions, porosity, cracks, penetration defects and fusion defects. The tensile strength determined shall be not less than the minimum of the specified tensile range of the parent metal nor more than 25 percent higher than that of the parent metal.

4.1.3 *Notched Bend Test*

4.1.3.1 *Procedure* — The edges of the notched specimens prepared as in **4.1.1** shall have a radius equal to 0·1 t where t is the thickness of the plate.

Root and face bend test procedure — One specimen each with the root and the face in tension shall be bent round a former whose diameter shall be the same as specified for the bend test of the parent metal. The angle at which the first sign of crack exceeding 1·5 mm in any direction appears shall be recorded and then the bending continued until total failure.

Free bend test procedure — Two gauge lines spaced at t, where t is the thickness of plate, shall be lightly scribed on the face of the weld. The gauge length (distance between gauge lines) shall be approximately in the centre of the width of the weld face and shall be measured to the nearest 0·1 mm.

Each specimen may be bent initially by the use of a suitable fixture. The surface of the specimen containing the gauge lines shall be directed towards the supports. The weld shall be at midspan of both the supports and the loading block. Alternatively, the initial bend may be made by holding each specimen in the jaws of a vice with one-third the length of the specimen projecting from the jaws, then bending the specimen away from the gauge lines through an angle of 30° to 45° by blows of a hammer. The other end of the specimen shall be bent in the same way. In order that the final bend shall be centered on the weld, the initial bends shall be symmetrical with respect to the weld, and both ends shall be bent through the same angle. The initial bend may also be started at the weld by placing the specimen in a guided-bend test jig.

Compressive forces shall be applied to the ends of the specimen, continuously decreasing the distance between the ends. (Any convenient means, such as a vice or testing machine, may be used for the final bend.) When a crack or other open defect exceeding 1·5 mm in any direction appears on the convex face of the specimen, the load shall immediately be removed. If no crack appears, the specimen shall be bent double. Cracks occuring on the corners of the specimen during testing shall not be considered.

The elongation shall be determined by measuring the minimum distance between the gauge lines, along the convex surface of the weld to the nearest 0·1 mm and subtracting the initial gauge length. The percent elongation shall be obtained by dividing the elongation by the initial gauge length and multiplying by 100.

4.1.3.2 *Assessment of notched bend test*

Assessment of root and face bend test — The minimum angle at which the first sign of crack appears shall be not less than 120°. Their nature of fracture, whether ductile or brittle shall be recorded. The fractured ends of the specimens shall be free from defects, such as slag inclusions, porosity, cracks, penetration defects and fusion defects.

Assessment of free bend test — The minimum elongation shall be not less than twice the elongation specified for the parent metal in the conventional tensile test.

4.2 Butt Welds in Pipe (Outside Diameter Less than 89 mm)

4.2.1 *Welding and Preparation of Test Pieces* — Two lengths of pipe of the same material and thickness and each at least 110 mm long shall be welded together to form a test piece which is then drilled according to Fig. 3, the diameter of holes being such that the cross-sectional area at notch is reduced by at least 45 percent. The edge preparation shall be in accordance with the appropriate codes and specifications. Table 3 gives examples to steel pipes to IS : 1161-1968*. The test specimens may be cut directly from the welded pipe and individual specimens flattened. Alternatively, the welded pipe may be cut into two parts along the axis and each half thus produced may be flattened, drilled and cut into individual specimens. The weld bead shall then be machined flush and edges of the notch given a smooth radius.

4.2.2 *Notched Tensile Test*

4.2.2.1 *Testing procedure* — The test specimens obtained as in **4.2.1** shall be pulled apart in a conventional tensile testing machine equipped with flat wedge grips and the maximum load at rupture shall be determined. The tensile strength in kgf/mm² shall be obtained by dividing the maximum load by cross-sectional area (width × thickness).

*Specification for steel tubes for structural purposes (*second revision*).

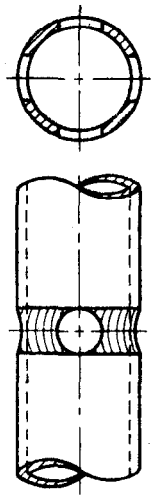


FIG. 3 EXAMPLE OF A NOTCHED PIPE TENSILE TEST SPECIMEN WITH FOUR HOLES

TABLE 3 HOLES FOR SEAMLESS STEEL TUBES CONFORMING TO IS : 1161-1968*

(*Clause* 4.2.1)

NOMINAL BORE	OUTSIDE DIAMETER	INSIDE DIAMETER	THICKNESS	CROSS-SECTIONAL AREA	DIAMETER OF HOLES TO BE DRILLED	NO. OF HOLES	REDUCTION IN CROSS-SECTIONAL AREA		RESIDUAL CROSS-SECTIONAL AREA
mm	mm	mm	mm	mm^2	mm		mm^2	Percent	mm^2
25	33·7	28·4	2·65	258	12	4	127	49	131
40	48·3	42·5	2·90	414	10	7	203	49	211
65	76·1	69·6	3·25	744	10	11	358	48	386
90	101·6	93·5	4·05	1 240	12	12	583	47	657
125	139·7	130·7	4·50	1 910	16	12	865	45	1 045
175	193·7	182·9	5·40	3 190	16	17	1 469	43	1 721
200	219·1	207·9	5·60	3 760	18	17	1 714	46	2 046

*Specification for steel tubes for structural purposes (*second revision*).

4.2.2.2 *Assessment of notched tensile test* — Fractured ends of the broken test piece shall be visually examined and the nature of fracture, that is, whether ductile (silky) or brittle (crystalline) shall be recorded. The fracture shall be free from defects, such as slag inclusions, porosity, cracks, penetration defects and fusion defects. The tensile strength determined as per clause **4.2.2.1** shall be not less than the minimum of the specified tensile range of the parent metal not more than 25 percent higher than that of the parent metal.

4.2.3 *Notched Bend Test*

4.2.3.1 *Test procedure* — The edges of the notch of specimens prepared as in **4.2.1** shall have a radius equal to 0·1 t where t is the thickness of the plate.

Root and face bend test procedure — One specimen each with the root and the face in tension shall be bent round a former whose diameter shall be the same as specified for the bend test of the parent metal. The angle at which the first sign of crack exceeding 1·5 mm in any direction appears shall be recorded and then the bending continued until total failure.

Free bend test procedure — Two gauge lines spaced at t, where t is the thickness of pipe, shall be lightly scribed on the face of the weld. The gauge length (distance between gauge lines) shall be approximately in the centre of the width of the weld face and shall be measured to the nearest 0·1 mm.

Each specimen may be bent initially by the use of a suitable fixture. The surface of the specimen containing the gauge lines shall be directed towards the supports. The weld shall be at midspan of both the supports and the loading block. Alternatively, the initial bend may be made by holding each specimen in the jaws of the vice with one-third the length of the specimen projecting from the jaws, then bending the specimen away from the gauge lines through an angle of 30° to 45° by blows of a hammer. The other end of the specimen shall be bend in the same way. In order that the final bend shall be centered on the weld, the initial bends shall be symmetrical with respect to the weld, and both ends shall be bent through the same angle. The initial bend may also be started at the weld by placing the specimen in a guided-bend test jig.

Compressive forces shall be applied to the ends of the specimen, continuously decreasing the distance between the ends. (Any convenient means, such as a vice or testing machine, may be used for the final bend.) When a crack or other open defect exceeding 1·5 mm in any direction appears on the convex face of the specimen, the load shall immediately be removed. If no crack appears, the specimen shall be bent double. Cracks occuring on the corners of the specimen during testing shall not be considered.

The elongation shall be determined by measuring the minimum distance between the gauge lines, along the convex surface of the weld to the nearest 0·1 mm and subtracting the initial gauge length. The percent elongation shall be obtained by dividing the elongation by the initial gauge length and multiplying by 100.

4.2.3.2 *Assessment of notched bend test*

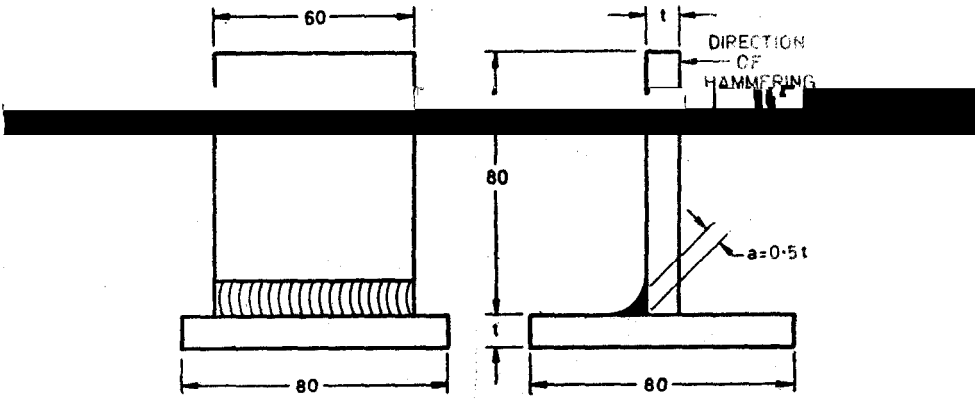
Assessment of root and face bend test — The minimum angle at which the first sign of crack appears shall be not less than 120°. The nature of the fracture, whether ductile or brittle shall be recorded. The fractured ends of the specimens shall be free from defects, such as slag inclusions, porosity, cracks, penetration defects and fusion defects.

Assessment of free bend test — The minimum elongation shall be not less than twice the elongation specified for the parent metal in the conventional tensile test.

5. TESTING OF FILLET WELDS IN PLATES

5.1 Bend over Test

5.1.1 *Welding and Preparation of Test Pieces* — Two pieces of plates of the same thickness and material and having dimensions shown in Fig. 4 shall be welded together into a Tee as shown in Fig. 4. Two such test specimens shall be prepared by welding, one immediately after the other.



All dimensions in millimetres.

FIG. 4 BEND OVER TEST SPECIMEN

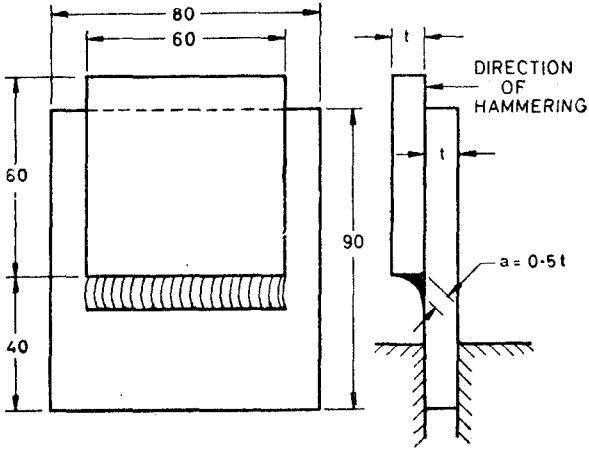
5.1.2 *Testing Procedure* — The test specimens may either be clamped in a vice and fractured by hammer blows or bent in a press until fracture occurs at the weld. The direction of hammering or pressing shall be as shown in Fig. 4.

5.1.3 *Assessment* — The fractured surfaces shall be visually examined for the nature and extent of defects. The fractured surfaces shall be free from slag inclusions, porosity, cracks, penetration defects and fusion defects.

5.2 Wedge Test

5.2.1 *Welding and Preparation of Test Pieces* — Two pieces of plates of the same material and thickness and dimensions shown in Fig. 5 shall be welded together to form a lap fillet weld as shown in Fig. 5. Two such specimens shall be prepared by welding, one immediately after the other.

5.2.2 *Testing Procedure* — The specimens may be either clamped in a vice and fractured by hammering sideway as in the direction shown in Fig. 5, or forced apart with the aid of a wedge or chisel as shown in Fig. 6 until fracture occurs at the weld.



All dimensions in millimetres.

FIG. 5 WEDGE TEST SPECIMEN

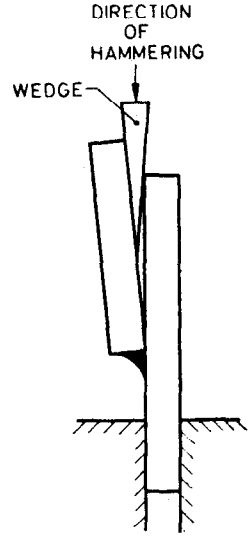


FIG. 6 SPLITTING THE WEDGE TEST SPECIMEN WITH A WEDGE

5.2.3 *Assessment* — The fractured surfaces shall be visually examined for the nature and extent of defects. The fractured surfaces shall be free from slag inclusions, porosity, cracks, penetration defects and fusion defects.

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117/418 B Sarvodaya Nagar, KANPUR 208005	21 68 76 21 82 92
Patliputra Industrial Estate, PATNA 800013	6 23 05
T.C. No. 14/1421, University P.O., Palayam TRIVANDRUM 695035	6 21 04 6 21 17

Inspection Offices (With Sale Point):

Pushpanjali, First Floor, 205-A West High Court Road, Shankar Nagar Square, NAGPUR 440010	2 51 71
Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005	5 24 35

*Sales Office in Calcutta is at 5 Chowringhee Approach, P. O. Princep Street, Calcutta 700072 — 27 68 00

†Sales Office in Bombay is at Novelty Chambers, Grant Road, Bombay 400007 — 89 65 28

‡Sales Office in Bangalore is at Unity Building, Narasimharaja Square, Bangalore 560002 — 22 36 71

Reprography Unit, BIS, New Delhi, India